of starch known as Brazilian arrowroot or tapioca meal, from which the tapioca of the shops is prepared by simply torrefying the moist starch upon hot plates, the heat causing the starch grains to swell and burst and become agglutinated together. A sauce called *cassareep*, used for flavoring soups and other dishes, particularly the West Indian dish known as pepper-pot, is also prepared from this juice by concentrating and rendering it harmless by boiling. Another of the products of cassava is an intoxicating beverage called *piwarrie*, but the manner of preparing it is not calculated to render it tempting to Europeans. It is made by the women, who chew cassava cakes and throw the masticated material into a wooden bowl, where it is allowed to ferment for some days and then boiled. It is said to have an agreeable taste."

From the above analysis of cassava root, descriptions of its uses and the amount of it that can be produced per acre, it is evident that it is destined to become a valuable agricultural product of the sub-tropical portions of our country.

Washington, D. C.

Histology of the leaf of Taxodium. I.

STANLEY COULTER.

(WITH PLATE XI.)

Following Endlicher, in his *Synopsis Coniferarum*, 1847, Taxodium distichum is placed in the sub-order Cupressineæ. Sachs suggests, however, that this arrangement of the Coniferæ can only be considered tentative, until further light is thrown upon the nature of female flowers of various genera.[1] As it is not the purpose of this paper to present any fact regarding this point, a general description of the appearance of the tree is alone given.

Under favorable circumstances, Taxodium distichum, the Ahuahete of the Mexicans, "reaches a height of 150 feet, with a trunk diameter of from 10 to 12 feet or more."[2] According to Humboldt, attaining a height of 120 feet, it has a diameter of from 32 to 40 feet.[3] It bears linear, acute, 2-ranked, crowded and deciduous leaves, from 5 to 8 mm. long, upon slender leafy branchlets, a part of which are also deciduous in autumn. Its range in the United States is from southern Delaware to southern Florida near the coast, and from Carroll county, Indiana, southern Illinois and Missouri, southward to Alabama, Louisiana and eastern Texas.[4]

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[1] Sach's Text Book of Botany, 1st English Ed., p. 459.
[2] Sargent's Catalogue of the Forest Trees of N. A., p. 65.
[3] Aspects of Nature II, p. 94.
[4] Sargent's Catalogue Forest Trees of N. A. l. c.

Of extreme beauty and grace, it is the most frequently planted of the hardy deciduous Conifers for ornament,[5] while its light, compact and durable wood gives it a great value from an economic standpoint. In our own state (Indiana), while its range commences as far north as Carroll county, it is not found in any abundance until we reach the low lands of the lower stretches of the Wabash, where its large trunk with its pale, smoothish bark and its yew-like foliage, makes it a striking feature in the landscape.

In the study of the foliage leaf, great difficulty was encountered in the securing of sections in which tissues were not either lacerated by the razor or distorted by pressure. The strongly cuticularized epidermal cells and the extremely thin-walled cells of the mesophyll, may in a certain measure account for this. Various methods of imbedding were tried, but none succeeded. The method of Moll[6] brought some hope with it, although it was suggested in the article that with fully grown parts, perfect imbedding was extremely doubtful. A careful following of directions there given gave no satisfactory results, nor was any greater success attained in cases in which a portion of the epidermis had been removed.

The sections used in the study are therefore all free-hand, but so large a number of these was prepared that the results attained are considered accurate.

The gross appearance of the leaf is shown in fig. 1, in which "B" shows a leafy branchlet with its crowded 2-ranked, linear leaves, natural size; while "A" gives a single leaf in position, magnified 12 diameters.

In some of the leafy branches the leaves show a marked tendency to depart from their distichous arrangement, in some cases almost forming whorls, in others taking positions referable to no definite plan. Specimens received from different localities show such a variation in habit and size of foliage that it is not strange that many varieties and some species have been founded upon them.

I have in these studies made constant comparisons with the structure of the foliage leaf of Pinus sylvestris, which may perhaps be taken as a fair representative of that genus.

In transverse section, the leaf presents an almost perfectly elliptical outline, the variations consisting in the somewhat acute form in the direction of the longer axis, and a depres-

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[5] Hemsley's Hardy Trees, Plants and Shrubs, p. 451; Paxton's Bot'l Dict'y, p. 549.

[6] BOTANICAL GAZETTE, xiii. 5.

sion on both leaf surfaces in the direction of the shorter axis (fig. 2).

In passing from the periphery to the center, three distinct regions are to be noticed: (1) A well-defined epidermal system; (2) the mesophyll, made up for the most part of somewhat large parenchymatous cells; (3) the fibro-vascular bundle near the center.

I. *Epidermal system.*—The epidermal cells in transverse section show a slight irregularity both in size and shape. The prevailing form appears to be elliptical, with the longer diameter, in the line of the greater leaf axis, to the shorter as two or three to one. In the depressions referred to above, which occur immediately above and below the fibro-vascular bundle, the cells become more nearly equal in their diameters, and in some cases that in the direction of the shorter leaf axis is the greater. At the extremities of the longer leaf axis the epidermal cells are somewhat peculiarly modified. The extreme cell is ordinarily much smaller than those on either side, which by their excessive development and remarkably thickened inner walls separate it entirely from the underlying parenchyma. In occasional cases this modification of the adjacent cells is not so marked, but there is found instead one or more rows of thick-walled "strengthening cells," extending from the apical cell back into the parenchyma. This arrangement is evidently a special one, as nowhere else does the epidermis show the slightest tendency to become of two layers, and at this point the mode of its occurrence is such that it probably can not be referred to this condition. In these smaller apical cells, the walls are of comparatively great thickness, almost obliterating the cell cavity. No marked differences are to be observed in this section between the epidermal cells of the outer and inner surfaces, unless it be that in the latter the average cell length is less than in the former. (See figs. 2, 3, 4 and 5.)

A surface slice (fig. 6) shows the epidermal cells to be of somewhat irregular outline, with their diameters of varying proportion to each other. They are, however, more nearly isodiametric than would be expected in a plant with narrow linear leaves, in which case, according to de Bary, "the longitudinal diameter is greatly extended."[7] The outer walls are heavily cuticularized and in nearly equal degree throughout the outline of the leaf. The cuticular layers are extremely dense and tough. The non-cuticularized layer is rela-

[7]De Bary, Comparative Anatomy of Phanerogams and Ferns, p. 30.

tively thick, and shows no tendency to thin out where it borders upon the cuticular layers. In this it resembles the condition in Pinus, and differs from that found in the under surface of the leaf of Taxus baccata, in which the non-cuticularized layers are scarcely to be detected where they border upon the cuticular.[8]

The cuticularized portions follow the outer surface of the epidermal cells and project inward in somewhat sharply-pointed conical form. In many instances the cuticular layer is largely developed at the stomatic furrow, although as a rule this may not hold.

The epidermal cells contain nothing further than the characteristic contents of such cells, although in the cuticular layers are found thickly massed granules, presumably calcium oxalate, as treatment with acetic acid produced no effect, and as this substance is not uncommon in the Cupressineæ.[9] No crystalline forms were found, and although the substance was present in comparatively large quantities, no modification in the coloration of the epidermis could be detected. The walls of the epidermal cells, especially the inner ones, are extremely irregular and show numerous infoldings, which in some instances are very prominent. There seems to be no special order in their disposition, either as regards the individual cell or the other tissues of the leaf, although the larger forms are more frequently found in the region of the resin duct than elsewhere. It is also possible that those of the inner leaf surface may be more prominent than those of the outer. The purpose of these infoldings I have been utterly unable to determine, their irregular arrangement and development negativing every conjecture. In view of some facts to be presented later in this paper, it is at least within the range of possibility that they serve for purposes of support.

A median vertical longitudinal section illustrates still further these points (fig. 10). The apex of the leaf is formed by a continuation of the epidermal cells of the inner surface, the apical cell being of this series. The two cells immediately adjoining the apical cell of both the outer and inner surface are in immediate contact, no parenchyma intervening. Those of the outer surface are much modified in form, while those of the inner retain their normal shape. At the third cell from the apical cell, there occurs a peculiar modification, due either to the presence of extremely short

[8] De Bary, Comparative Anatomy of Phanerogams and Ferns, p. 77.

[9] De Bary, l. c., p. 102.

"strengthening cells," or to the division of the epidermal cell of the outer leaf surface into three layers. This arrangement serves, of course, to give still further rigidity to the leaf apex. At this part of the leaf the epidermal cells of the inner surface are much longer than those of the outer surface (as seen in this section), seeming in the one case to be lengthened, in the other shortened (figs. 9 and 10, cf. also fig. 3).

The stomata in surface slice appear widely elliptical and have the depressed position usually found in thick-skinned parts. In size, they are perhaps from one-third to one-half that of the surrounding epidermal cells, and are relatively equal to each other. The stomata are irregularly arranged in this view, both as regards the surrounding epidermal cells and the relation of their axes. In transverse section the guard cells are almost perfectly oval, with their outer walls heavily thickened or from three to five times thicker than their inner walls. This thickening appears to be greatest at or near the point of union with the subsidiary cells, but extends in an almost undiminished degree to the free ends. The free ends show no difference either in shape or size from the united ends, presenting a marked contrast to Pinus, in which the reverse is true. They meet each other at an angle of about 45° as referred to their longer diameter, and open into a remarkably large respiratory cavity. (Fig. 7.)

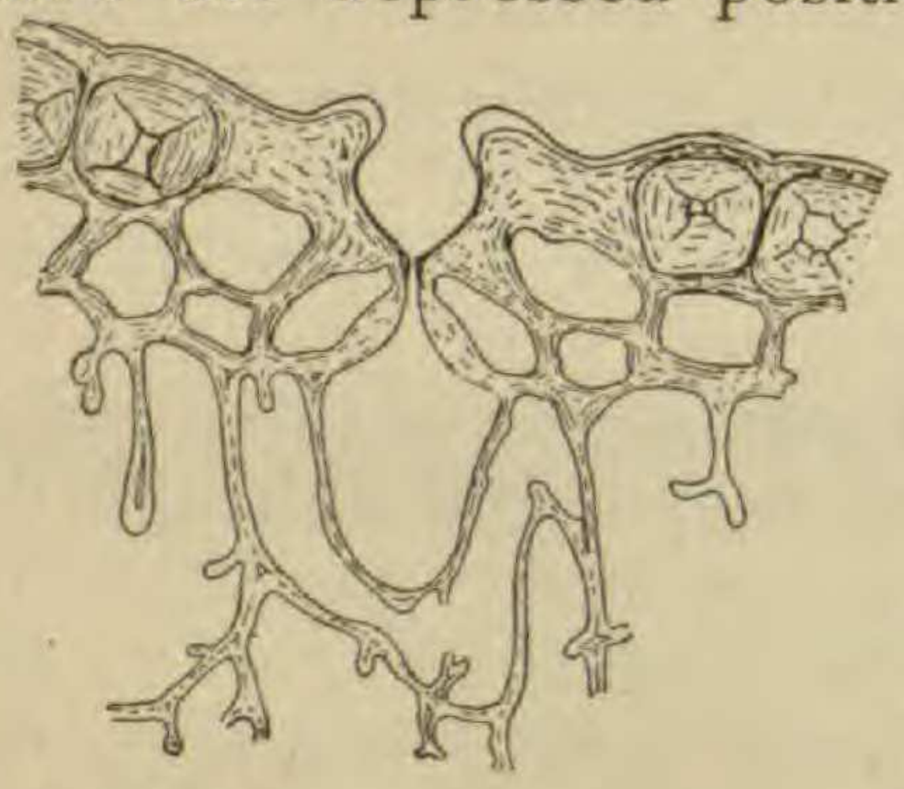

Fig. 8. Section of stoma of Pinus sylvestris × 650.

The adjoining epidermal cells are but slightly modified, those immediately adjacent having their lateral walls which join the guard cells modified in shape only as would be indicated by the outline of the guard cells. The inner walls of these cells are in most cases more irregular in outline and more heavily thickened than the ordinary epidermal cell.

The guard cells are depressed below the surface about one-half the height of the epidermal cells, so that in a surface slice it is necessary to focus down to bring them in view. The epidermal cells next removed from the subsidiary cells are somewhat shortened, becoming almost isodiametric as viewed in both transverse and surface sections. The subsidiary cells are also as a rule more heavily thickened and cu-

ticularized at the stomatic furrows than elsewhere. The intercellular cavity shows numerous and somewhat prominent infoldings, a characteristic common also to Pinus. The contents of the guard cells are protoplasm and chlorophyll with their included bodies.

A transverse section usually shows eight stomata, in relatively definite positions, six on the outer and two on the inner surface of the leaf. In exceptional cases the number may vary upon the outer surface, but in the sections examined no more than two have been detected upon the inner surface. Upon the upper surface the stomata are usually about equidistant from each other. Those of the inner surface seem to be placed about midway between perpendiculars let fall from two of the upper stomata. (Figs. 2, 3, 4, 5 and 7.)

The stomatic system seems to be of the simplest and is much different from that in Pinus sylvestris in the shape and thickening of guard-cells, in the modifications of the subsidiary and surrounding epidermal cells, and in the shape and outline of the furrow. The similarity consists chiefly in the relatively large respiratory cavities and the infoldings mentioned above. As a whole, in comparison with Pinus the stomatic mechanism seems much less completely developed both as regards its differentiation from the surrounding tissues and its means for controlling transpiration. (Cf. figs. 7 and 8.)

Purdue University, Lafayette, Ind.

OPEN LETTERS.

The "King-Devil."

In connection with Mr. Lester F. Ward's article on the "King-Devil" in the January GAZETTE, it may be interesting to note that *Hieracium aurantiacum* L. has appeared on my place here. The locality is in a wet meadow, and I first discovered it in the summer of 1884, when there was a single flowering stalk. This has increased slowly until last summer there were six or eight flowering stalks, but so far it has shown no indications of becoming a troublesome weed. As to the manner of its introduction, I can only say that my uncle, the late Mr. Oscar Harger, of New Haven, once had the plant growing in his garden, and it may have been introduced from there in some way, although as the distance is about fifteen miles, the probability seems small.

E. B. HARGER.

Oxford, Conn.